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(71) Applicant *(for all designated States except US):* THOMSON CONSUMER ELECTRONICS, S.A. [FR/FR]; 9, place des Vosges, La Défense 5, F-92400 Courbevoie (FR).

(72) Inventors; and
(75) Inventors/Applicants *(for US only) :* DIEHL, Eric [FR/FR]; 12, rue de Belfort, F-67000 Strasbourg (FR). AMSTOUTZ, Marc [FR/FR]; 20, rue de Molsheim, F-67100 Strasbourg (FR).

(74) Agents: EINSEL, Robert et al.; Deutsche Thomson-Brandt GmbH, Göttinger Chaussee 76, D-3000 Hannover 91 (DE).

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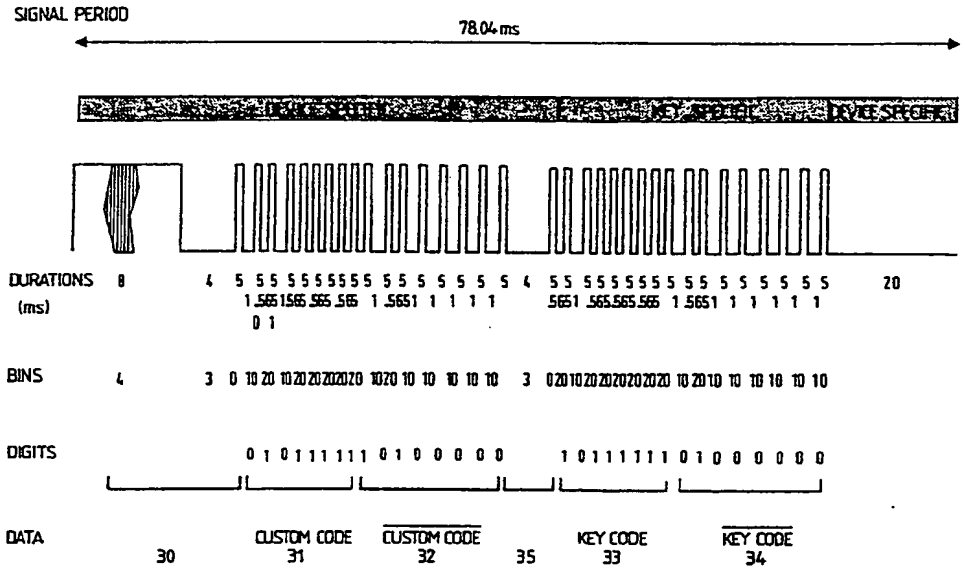
(54) Title: METHOD OF COMPRESSING DATA CODE AND APPARATUS FOR USING THE COMPRESSED DATA CODE

(57) Abstract

For compressing IR remote control code sequences the methods of categorization and removing-repeats are known. Categorization is a technique which consists of creating a table with the different duration classes found in the code. With the method of removing-repeats the bins suite representing a code sequence can be reduced to the bins representing the preamble and one repeat plus the additional informations repeat number and preamble length. But the compression factor is low. According to the invention, within the data of all used functions for different devices multiple existing patterns are extracted which can be coded with fewer bytes than the original code sequences. There are some fixed parameters (Carrier frequency, Preamble period, Repeat period, Preamble length, Repeat number, Bins table), synchronization bins (Mark, Space, Sync, Frame space), and some custom-specific data. The non-common parts are the key-specific data. A bins table contains all existing bins. A device table defines the sequence of elements which compose the code (device-specific or key-specific bins and data). A key table stores data of the key-specific part.



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Method of Compressing Data Code and Apparatus for Using the Compressed Data Code

The present invention relates to a method of compressing data code, for example IR remote control code, and to an apparatus for using the compressed data code.

Background

For compressing IR (infra-red) remote control code some methods are known. In US 4,623,887 the methods of categorization and removing-repeats are described. Categorization is a technique which consists of creating a table with the different duration classes found in the code. A duration class number is called a bin. The code can be so expressed as a suite of bins.
An IR code is composed of a beginning frame called preamble (which cannot exist) and some repeated frames called repeats (always existing). The repeat frame is normally played while the key is pressed. US 4,623,887 gives an algorithm to automatize the removing-repeat method.

Invention

It is one object of the invention to disclose a method of even stronger data code compression. This object is reached by the inventive method disclosed in claim 1.

In principle the inventive method consists in compressing data code, for example remote control code, using pulse width categorization and removing-repeats, whereby data code can be coded for controlling different devices and the compressed code consists of an invariant device-specific part and of a variant function-specific part, whereby patterns are identified in the data of the code sequences for said devices and assigned to a device table and function-specific data are assigned to a keys

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table, whereby respective data of said device table point to the corresponding data within said keys table.

Advantageous additional embodiments of the inventive method are resulting from the respective dependent claims.

It is a further object of the invention to disclose an apparatus which utilizes the inventive method. This object is reached by the inventive apparatus disclosed in claim 6.

In principle the inventive apparatus consists of a memory 61 - for example a ROM - which stores program code and data code for code sequences which are compressed according to the inventive method, of a keyboard 63, of a following microprocessor 62 which reads from memory 61 the respective compressed code and de-compresses this code and sends it via an IR transmitter 64 to a device which shall be controlled.

Advantageous additional embodiments of the inventive apparatus are resulting from the respective dependent claims.

The inventive code compression goes beyond the known compression methods. The first purpose is to recognize some specific patterns within function and key codes, respectively, which represent data digits, and extract these patterns from the code sequence signal. The second purpose is to store the code sequences of different functions and keys from the same hand set, respectively, in a stronger compressed format. The more key and/or device codes are compressed, the more efficient the compression is.
One principle of this inventive compression method is to distinguish the invariant part of all the key codes called device-specific part and the variant part of the frame called key-specific part. Patterns of digits of code sequences for different devices which shall be controlled are then identified. Thereafter the compression reduces the data of the key-specific part for all the keys and generates an increased device-specific part and a decreased key-specific part of data. Finally, the

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code is formatted corresponding to the defined format for the specific handset.

The total code compression is the result of several steps. Each step corresponds to a different compression principle. To achieve the full compression the following steps are used:
- Categorization;
- Removing-repeats;
- Patterns identification;
- Handset oriented format.

1) Categorization
The principle is described in paragraph 'background'.

2) Removing-repeats
The principle is described in paragraph 'background'. With these observations the bins suite representing a code sequence can be reduced to the bins representing the preamble and one repeat plus two additional informations: repeat number and preamble length.

3) Patterns identification
In an IR code frame, some parts represent functional data. Within the data of all used functions for different devices multiple existing patterns are extracted which can be coded with fewer bytes than the original code sequences.
Each data digit corresponds to a specific transmission mode. There are many existing transmission modes but the most common are Pulse Period Modulation (P.P.M.) and Phase Modulation (P.M.). The inventive code format will preferably code these transmission modes. As most of the codes contain binary digits only binary coded data become integrated.

4) Handset oriented format
All the code sequences of a specific device contain some common parts. There are some fixed parameters (Carrier frequency, Preamble period, Repeat period, Preamble length, Repeat number, Bins table), synchronization bins (Mark, Space, Sync, Frame

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space), and some custom-specific data. The non-common parts are formed to pure key-specific data. A table defines the sequence of elements which compose the code (device-specific or key-specific bins and data), the device table. The format consists of a device-specific part containing the fixed parameters and the device table, and a key-specific part containing the keys data.

Because of the high code compression one may advantageously control without the need of high code storage capacity a lot of devices which need different codes, e.g. TV's, VCR's, CD players, amplifiers, even if they stem from different manufacturers.

The inventive code compression is not limited to IR remote control codes. Also codes in other technical fields can be compressed, for example ultrasonically transmitted code sequences or codes for remote controlled car port door openers.

Drawings

Preferred embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 shows an example of categorization;
Fig. 2 shows data expressed in P.P.M. and P.M. format;
Fig. 3 shows an IR signal with different compression steps;
Fig. 4 depicts compressed code obtained from the signal of Fig. 3;
Fig. 5 explains the data structure of a compressed IR code;
Fig. 6 shows the block diagram of an inventive apparatus.

Preferred embodiments

Fig. 1 shows an example of categorization. The code pulses can be divided into four different time duration groups: 1, 2, 3 and

5. In the bins table these time duration groups are matched to four numbers (0, 1, 2 and 3) which can be expressed with a reduced number of bits. The total code sequence can than be expressed as 0,2,0,2,0,1,0,1,3.

Fig. 2a shows a P.P.M. code sequence and Fig. 2b a P.M. code sequence for the same data.

In Fig. 3 a code sequence is depicted which consists of a part DEVICE SPECIFIC and a part KEY SPECIFIC.
In general, the device-specific part of the compressed code uses the following data:

d1) Digits coding/Frequency: 2 bytes (with bits 0 ... F)

F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0
DIGITS_CODING	COMMON_BIN	U	U	FREQUENCY											

d1.1) DIGITS_CODING
0: Pulse Period Modulation (P.P.M.). The binary digits are expanded as two bins at opposite levels. The level of the first bin is also the opposite level of the preceding bin (or high level if it is the first bin). The bins value depends of the COMMON_BIN value.
1: Phase Modulation (P.M.). The binary digit '0' is expanded as a bin 0 at low level followed by a bin 0 at high level (rising edge). The binary digit '1' is expanded as a bin 0 at high level followed by a bin 0 at low level (falling edge).

d1.2) COMMON_BIN (used if DIGITS_CODING is 0)
0: Common bin is the first one, so digit '0' is represented by BIN0-BIN1 and digit '1' by BIN0-BIN2.
1: Common bin is the second one, so digit '0' is represented by BIN1-BIN0 and digit '1' by BIN2-BIN0.

d1.3) U
Unused bit.

BNSDOCID: <WO__9305580A1_I_>

d1.4) FREQUENCY

0: No modulation (flash mode).

1 ... 4095: 8*Carrier frequency [kHz] (carrier frequency 0 ... 511.875 kHz can be coded).

d2) Preamble and Repeat period: 5 bytes

```
 7 6 5 4 3 2 1 0
+-------+-------+
     PERSHH

 F E D C B A 9 8 7 6 5 4 3 2 1 0
+-------------------------------+
        PREAMBLE_PERIOD

 F E D C B A 9 8 7 6 5 4 3 2 1 0
+-------------------------------+
         REPEAT_PERIOD
```

d2.1) PERSHH (2 nibbles)

$[PERSHH_{7-4}]$*65535+PREAMBLE_PERIOD

0 ... 1048576: Preamble period length in 8/3.5MHz = 2.286µs units (0 ... 2396.7 ms). This period is used to compute the space to add at the end of the preamble frame.

$[PERSHH_{3-0}]$*65535+REPEAT_PERIOD

0 ... 1048576 : Repeat period length in 2.286µs units. This period is used to compute the space to add at the end of the repeat frame.

d2.2) PREAMBLE_PERIOD

0 ... 65535 times 2.286µs units

d2.3) REPEAT_PERIOD

0 ... 65535 times 2.286µs units

SUBSTITUTE SHEET

d3) Preamble length: 1 byte

```
 7 6 5 4 3 2 1 0
+---------------+
 PREAMBLE_LENGTH
```

d3.1) PREAMBLE_LENGTH
0 ... 255: Number of bins composing the preamble.

d4) Repeat number: 1 byte

```
 7 6 5 4 3 2 1 0
+---------------+
  REPEAT_NUMBER
```

d4.1) REPEAT_NUMBER
0 ... 255: Number of times to play the repeat (repetition part of the code).

d5) Bins table: 1+2*BINS_NUMBER bytes

This table contains the bin durations used for the code sequences. The BIN0-2 are ordered in such a way that for P.P.M. coding (DIGITS_CODING = 0), BIN0 is the common digit-bit and BIN1-2 the two other digit-bins. For P.M. coding (DIGIT_CODING = 1), BIN0 is the base bin.

```
 7 6 5 4   3   2   1   0
+-+-+-+-+-----------+
 U U U U BINS_NUMBER

 F E D C B A 9 8 7 6 5 4 3 2 1 0
+-------------------------------+
              BIN 0
              BIN 1
```


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d5.1) U
Unused bit.

d5.2) BINS_NUMBER
0 ... 16: Number of elements (bins) of this table.

d5.3) BIN n
0 ... 65535: Bin duration in 2.286μs units (0 ... 149.794ms).

d6) Device table: 1 + TABLE_LENGTH bytes.

This table is unique and describes each code sequence as a suite of CODE characters and DATA characters.

```
 7 6 5 4 3 2 1 0
+---------------+
   TABLE_LENGTH
      CODE 0
      CODE 1
      DATA 1
```

d6.1) TABLE_LENGTH
0 ... 255: Number of elements (bytes) of this table.

d6.2) CODE n
There are 4 types of code characters in this table which are identified by their bits 7 and 6. Bit 7 indicates if the information is device-specific (bit 7 = 0) or key-specific (bit 7 = 1). Bit 6 indicates if the information is constituted of bins (bit 6 = 0) or bits (bit 6 = 1).

d6.2.1) Dev_Bins character: bit 7 = 0, bit 6 = 0.
This character indicates that a device-specific information constituted of bins is to be played. The information is stored in the next (BINS_NUMBER div 2) + (BINS_NUMBER mod 2) characters

where BINS_NUMBER is the value coded in bits 5 ... 0 of the dev-bins character. The first bin (nibble) to play is stored is the high nibble of the character next to the dev-bins character and so on. If the bins number is odd, the low nibble of the last character is unused.

```
 7 6 5 4 3 2 1 0
+-+-+-----------+
 0 0 BINS_NUMBER
+-------+-------+
   BIN0     BIN1
   BIN2      U
```

d6.2.1.1) BINS_NUMBER
0 ... 63: Number of bins (nibbles) to play contained after this character.

d6.2.1.2) BIN_0 ... BIN_{BINS_NUMBER} (DATA characters)
0 ... 16: Values of the bins to play.

d6.2.1.3) U
Unused nibble.

d6.2.2) Dev_Bits character: bit 7 = 0, bit 6 = 1.
This character identifies a digits section of the device-specific part of the code. The BITS_NUMBER value (bits 5 ... 0) is the number of bits to play. These bits are contained in the (BITS_NUMBER div 8) + ((BITS_NUMBER mod 8) > 0) characters contiguous to the dev_bits character. The first bit to play (a) is stored in the MSB of the character following the dev-bits character and so on (b ... j). If the bits number is not a multiple of 8, the lasts bits of the last character are unused. The way to play these bits depends of the DIGITS_CODING parameter.

BNSDOCID: <WO__9305580A1_I_>

```
 7 6 5 4 3 2 1 0
+-+-+-----------+
 0 1 BITS_NUMBER
+-+-+-+-+-+-+-+-+
 a b c d e f g h
 i j U U U U U U
```

d6.2.2.1) BITS_NUMBER
0 ... 63: Number of bits to play contained after this charac ter.

d6.2.2.2) a ... j (bits in DATA characters)
0 or 1: Bit values of Bit_0 ... Bit_{BITS_NUMBER}.

d6.2.2.3) U
Unused bit.

d6.2.3) Key_Bins character: bit 7 = 1, bit 6 = 0.
This character identifies a key-specific part in the frame coded as a suite of bins. The value coded in bits 5 ... 0 is the number of bins to play (BINS_NUMBER), contained in the keys table. The bins are stored in (BINS_NUMBER div 2) + (BINS_NUMBER mod 2) characters in the keys table. The first bin (nibble) to play stored is the high nibble of the first character of this group in the keys table and so on. If the bins number is odd, the low nibble of the last character is unused.

```
 7 6 5 4 3 2 1 0
+-+-+-----------+
 1 0 BINS_NUMBER
```

d6.2.3.1) BINS_NUMBER
0 ... 63 : Number of bins (nibbles) to play contained in the keys table.

d6.2.4) Key_Bits character: bit 7 = 1, bit 6 = 1.

This character identifies a digits section of the key-specific part of the code. The BITS_NUMBER value (bits 5 ... 0) is the number of bits to play. The bits are stored in (BITS_NUMBER div 8) + ((BITS_NUMBER mod 8) > 0) characters in the keys table. The first bit to play is stored in the MSB of the first character of this group in the keys table and so on. If the bits number is not a multiple of 8, the lasts bits of the last character are unused. The way to play these bits depends of the DIGITS_CODING parameter.

```
 7 6 5 4 3 2 1 0
+-+-+-----------+
 1 1 BITS_NUMBER
```

d6.2.4.1) BITS_NUMBER
0 ... 63: Number of digits (bits) to play contained in the keys table.

The keys-specific part of the compressed code uses the following data:

k1) Keys (Function) table: 2 + KEY_SIZE * KEYS_NB bytes

This table is accessed when encountering a Key_Bins or a Key_Bits character during the Device table reading. This table contains a succession of character groups which represent either some bins (corresponding to a Key_Bin character of the device table), or bits (which corresponds to a Key_Bits character of the device table). As the information is represented in nibbles (bins) or bits, it is filled with '0' in order to be stored in byte cells.

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```
 7 6 5 4 3 2 1 0
+---------------+
    KEY_SIZE
    KEYS_NB
   CHARACTER 0
   CHARACTER 1
```

k1.1) KEY_SIZE
0 ... 255: Size of a key in bytes.

k1.2) KEYS_NB
0 ... 255: Number of keys (in order to know the size of the keys table).

From the top to the bottom in Fig. 3 one can see the code signal, the corresponding pulse durations, the bins obtained with categorization, the P.P.M. binary digits and data they represent.

Fig. 4 shows the resulting compressed code of the signal of Fig. 3 which is stored in a memory using 35 bytes for 3 keys which represents a compression rate of 6 in comparison with the above mentioned categorization plus removing-repeats method. The following data and bits, respectively are depicted:

Fig. 4a) DIGITS_CODING DC = '0', COMMON_BIN CB = '1', a frequency code of '320' which represents a carrier frequency of 320/8kHz = 40kHz;
Fig. 4b) Value PERSHH with two nibbles '0';
Fig. 4c) Preamble period PBPER '0';
Fig. 4d) Repeat period PRTPER '34143' which corresponds to a lenght of 8/(3.5MHz)*34143 = 78.04ms;
Fig. 4e) PREAMBLE_LENGHT '0';
Fig. 4f) REPEAT_NUMBER '10';
Fig. 4g) A number of five elements is contained in the bins table, therefore BINS_NUMBER '5'. These bins have durations of 219, 438, 247, 1750 and 3500 times 2.286μs (0.5, 1, 0.565, 4 and 8 ms);

Fig. 4h) A number of nine elements is contained in the device table, therefore device TABLE_LENGHT '9'. The table contains:
- 3 Dev_Bins with BIN0 = 4, BIN1 = 3, BIN2 = 0; these bins correspond to period 30 in Fig. 3;
- 16 Dev_Bits 01011111 10100000; these bits correspond to periods 31 and 32 in Fig. 3;
- 2 Dev_Bins with BIN0 = 3, BIN1 = 0; these bins correspond to period 35 in Fig. 3;
- 16 Key_Bits; these bits are contained in the keys table in Fig. 4i and correspond to periods 33 and 34 in Fig. 3.

Fig. 4i) KEY_SIZE '2', KEYS_NB '2', KEYS TABLE with 16 bits '10111111 01000000' for key Nr.1 and 16 bits '00111010 11000101' for key Nr. 2.

Fig. 5 summarizes the general data structure of a compressed IR code. At the beginning of bar MODFRQ the values for DIGITS_CODING 501 and COMMON_BIT 502 are arranged. MODFRQ corresponds to Fig. 4a, SGNPER to Fig. 4b-d, PBLENGTH to FIG. 4e, RPTNB to Fig. 4f, BINSTAB to Fig. 4g, DEVTAB to Fig. 4h and KEYSTAB to Fig. 4i.
If, for example, a key of an IR remote control is pressed, the corresponding data stored in the keys table is read. According to the controlled device the respective device table is selected. If the respective key does need also key-specific code which can not be expressed alone with the patterns contained in the device table, the code in the device table points to respective bits in the keys table.

Fig. 6 shows the block diagram of an inventive device, for example an IR remote control unit, which uses compressed code. A memory 61, for example a ROM, stores program code and the data for the code sequences which had been compressed according to the inventive method. If a user presses a key of keyboard 63, a following microprocessor 62 reads from memory 61 the respective compressed code for the selected device, de-compresses this code and sends it via an IR transmitter 64 to the device which shall be controlled.

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Advantageously the inventive device can read and compress code received from other IR remote control units using a light sensitive element or an other data input. In this case a second memory connected to microprocessor 62 may store the compressed code. The memory 61 stores the program for compressing the received code sequences.

The inventive Patterns identification permits to reduce the size of n bins coded in n*4 bits (nibbles) to n/2 bits (plus a control byte). The compression rate tends to 8. Although some IR codes do not have the patterns identified (P.P.M. and P.M.) the inventive code compression is useful for 90% of the existing IR codes.

The efficiency of the inventive handset-oriented format is more variable between some IR codes. It depends on the key-specific proportion of the code and almost the keys number. In the example shown in Fig. 4, one can see that an additional key only needs two supplementary bytes. For three keys, the medium compression rate approximately equals 3.3 and for 5 keys it is 4.6 . For 10 keys, it raises to 7.

Claims

1. Method of compressing data code, for example remote control code, using pulse width categorization and removing-repeats, characterized in that data code for controlling different devices can be coded and that the compressed code consists of an invariant device-specific part and of a variant function-specific part, whereby patterns are identified in the data of the code sequences for said devices and assigned to a device table and function-specific data are assigned to a keys table, whereby respective data of said device table point to the corresponding data within said keys table.

2. Method according to claim 1, characterized in that pulse period modulation code and/or phase modulation code is coded with said patterns.

3. Method according to claim 1 or 2, characterized in that said device-specific part contains said preamble length and said frame repeat number and said bins table and/or the carrier frequency and/or the preamble period and/or the frame repeat period and/or synchronization bins - e.g. mark, space, sync, frame space - and/or custom-specific data.

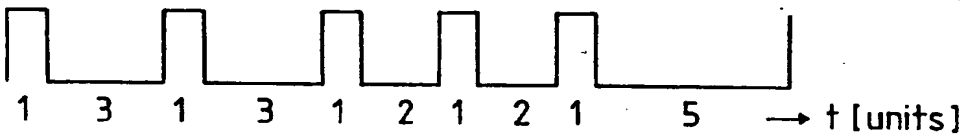
4. Method according to any of claims 1 to 3, characterized in that said carrier frequency is coded with a binary integer number which equals eight times the carrier frequency.

5. Method according to any of claims 1 to 4, characterized in that said preamble period and said frame repeat period and the duration of said bins is coded with binary integer numbers which equal respective times a time unit.

6. Apparatus for a method according to any of claims 1 to 5, consisting of memory (61) - for example a ROM - which stores program code and data code for code sequences which

are compressed according to the method disclosed in claims 1 to 6, of a keyboard (63), of a following microprocessor (62) which reads from memory (61) the respective compressed code and de-compresses this code and sends it via an IR transmitter (64) to a device which shall be controlled.

7. Apparatus according to claim 6, characterized in that said apparatus reads using a light sensitive element or an other data input and compresses code received from other IR remote control units, whereby an additional memory connected to said microprocessor (62) stores said compressed code.



Bins Table

0	1
1	2
2	3
3	5

Code sequence
0,2,0,2,0,1,0,1,3

Fig.1

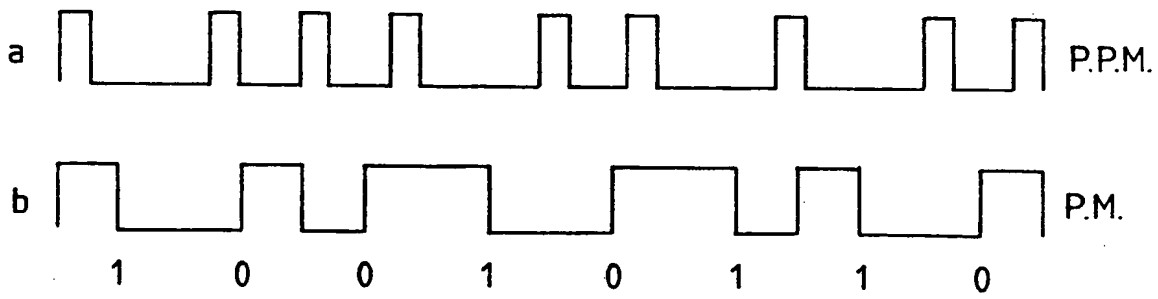


Fig.2

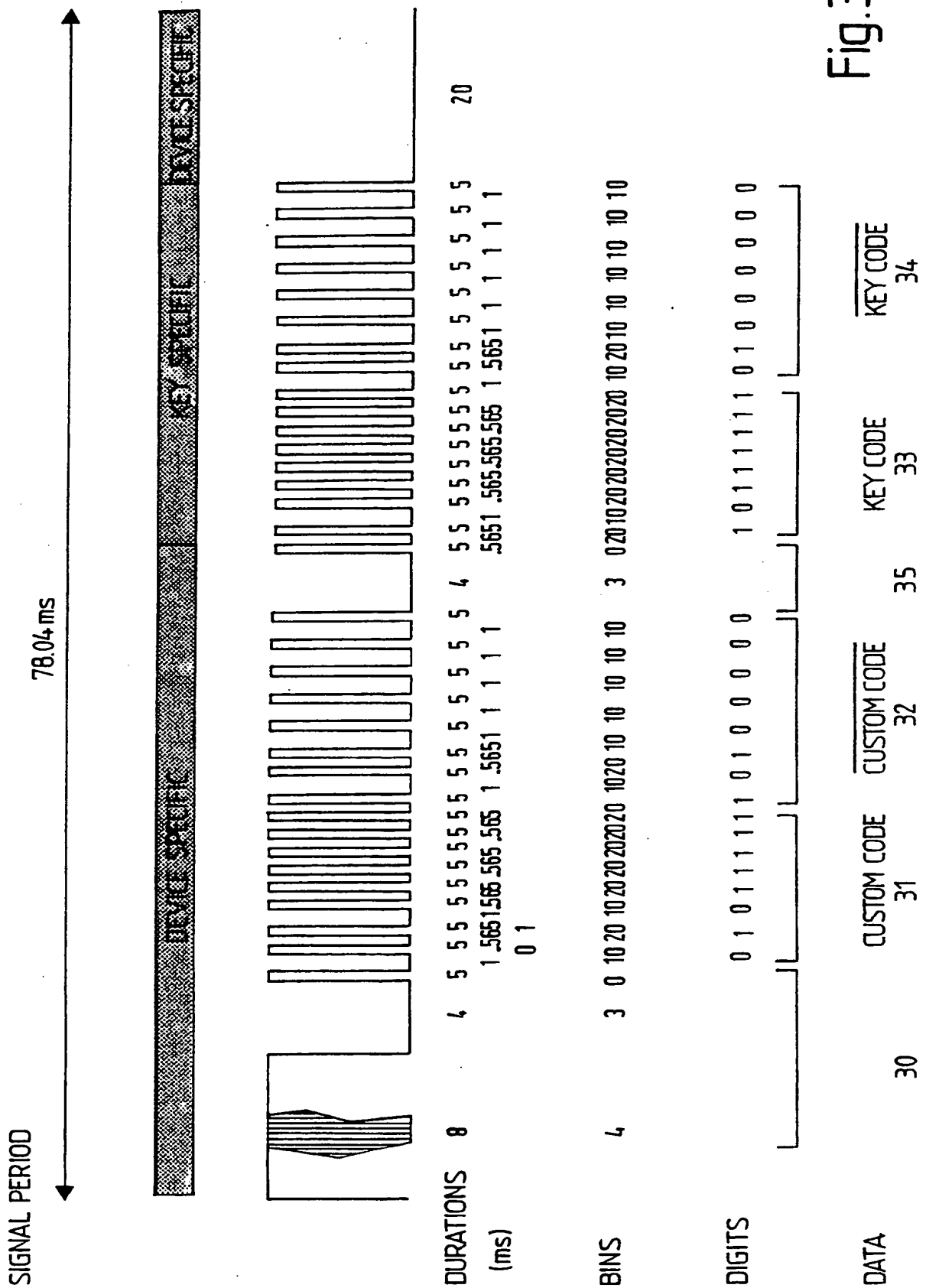

SIGNAL PERIOD
78.04 ms
DEVICE SPECIFIC
KEY SPECIFIC
BYTE SPECIFIC
DURATIONS (ms)
BINS
DIGITS
DATA
CUSTOM CODE
CUSTOM CODE
KEY CODE
KEY CODE
30
31
32
33
34
35

Fig.3

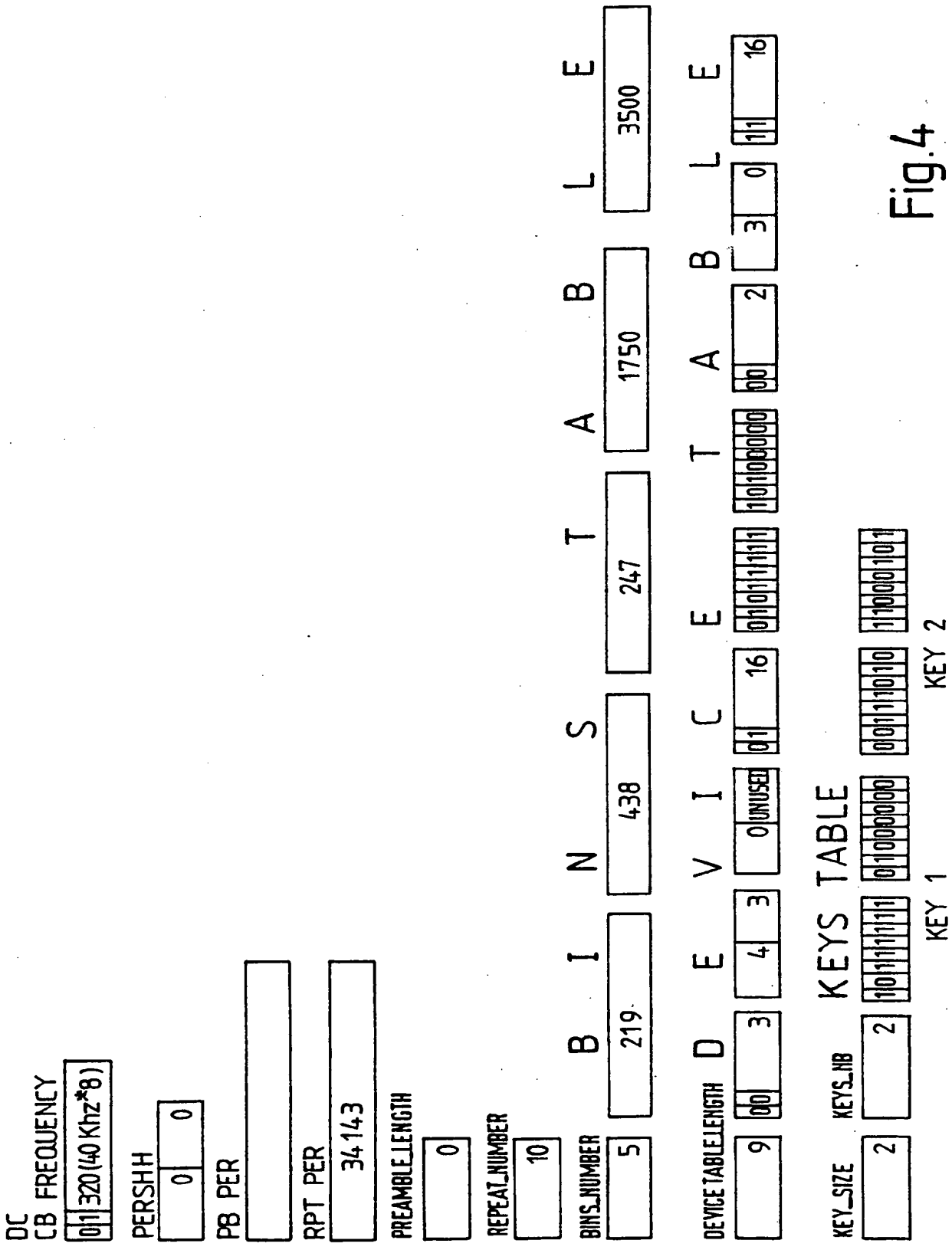


Fig.4

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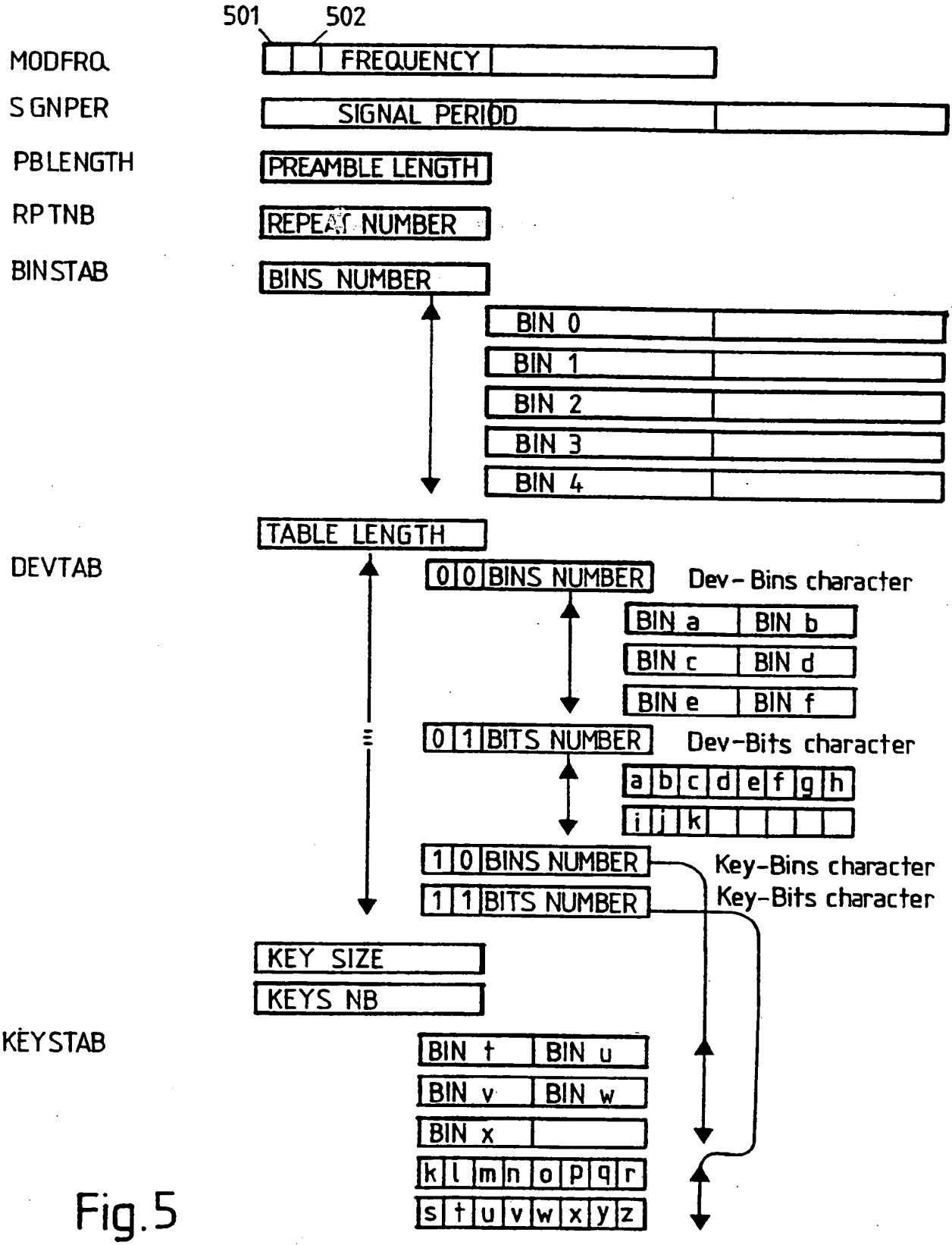
501
502
MODFRQ
FREQUENCY
SGNPER
SIGNAL PERIOD
PBLENGTH
PREAMBLE LENGTH
RPTNB
REPEAT NUMBER
BINSTAB
BINS NUMBER
BIN 0
BIN 1
BIN 2
BIN 3
BIN 4
TABLE LENGTH
DEVTAB
0 0 BINS NUMBER
Dev-Bins character
BIN a
BIN b
BIN c
BIN d
BIN e
BIN f
0 1 BITS NUMBER
Dev-Bits character
a b c d e f g h
i j k
1 0 BINS NUMBER
Key-Bins character
1 1 BITS NUMBER
Key-Bits character
KEY SIZE
KEYS NB
KEYSTAB
BIN t
BIN u
BIN v
BIN w
BIN x
k l m n o p q r
s t u v w x y z

Fig.5

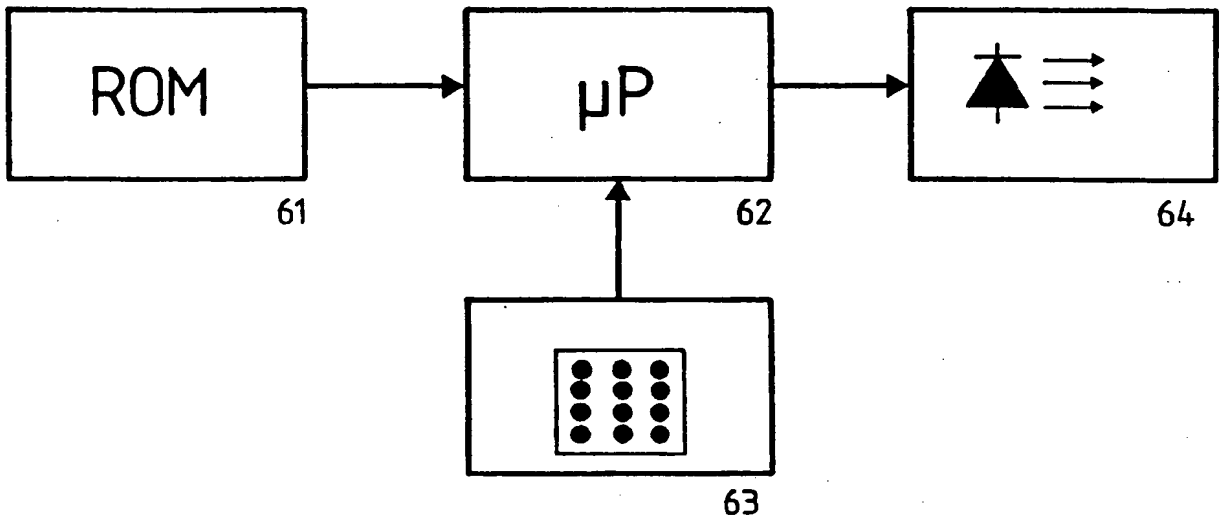

Fig.6

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INTERNATIONAL SEARCH REPORT

International Application No PCT/EP 92/01919

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 H03M7/30; G08C19/28

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	H03M ; G08C

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	US,A,4 866 434 (KEENAN) 12 September 1989	1-3,6,7
A	see column 2, line 40 - column 4, line 61; figures 1-3	4,5
A	EP,A,0 320 066 (NORTH AMERICAN PHILIPS) 14 June 1989 see column 20, line 50 - column 23, line 51; figure 8	1-7
A	US,A,4 623 887 (WELLES) 18 November 1986 cited in the application	

° Special categories of cited documents :[10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
23 NOVEMBER 1992	27. 11. 92
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	FEUER F.S.

Form PCT/ISA/210 (second sheet) (January 1985)

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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. EP 9201919 SA 63570

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 19/11/92
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